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CASE STUDY ON FLANGE PART MIX UP DEDUCTION SYSTEM AT BGL WITH THE USE OF LEAN SIX SIGMA FOR PRODUCTIVITY IMPROVEMENT

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Abstract
The fast changing economic conditions such as global competition, declining profit margin, customer demand for high quality product, product variety and reduced lead–time etc. had a major impact on manufacturing industries. To respond to these needs various industrial engineering and quality management strategies such as ISO 9000, Total Quality Management, Kaizen, Just–in–time manufacturing, Enterprise Resource Planning, Business Process Reengineering, Lean management etc. have been developed. A new paradigm in this area of manufacturing strategies is Lean Six Sigma. The Lean Six Sigma approach has been increasingly adopted worldwide in the manufacturing sector in order to enhance productivity and quality performance and to make the process robust to quality variations.

This paper discusses the quality and productivity improvement in a manufacturing enterprise through a case study. The paper deals with an application of Six Sigma DMAIC (Define–Measure-Analyze-Improve-Control) methodology in an industry which provides a framework to identify, quantify and eliminate sources of variation in an operational process in question, to optimize the operation variables, improve and sustain performance viz. The industrial situation has given a challenging task to analyze and identify the requirement of the industry. The process timing for every process has become a chance to view the errors happening in the industry. The error are record and plotted in the form of graph and data's. With the help of dataset have viewed the errors and identified the errors of improvement. The identified errors are found and improved to increase the productivity and quality of the system for about 49 % of the existing system.

Key Words: MUDA (Japanese: Waste), Lean Six Sigma, Value Stream Mapping.

Introduction

This project is done at – "BGL". They are the leading industries in south Asia established in 1937.they are the manufactures of Rolon chain, automobile parts and products. Our project is a sub-contract of BGL and Robert Bosh BGL manufactures flange at diesel engine pumps for Bosh. The plant has given a case study to optimize the production system to improve production time and to have a good rap pot among the internal customer.

This project is been expanded under the "Lean six sigma". The figure shows the Lean Six Sigma architecture DMAIC used in this study. The goal of the definition stage was to establish project goals and ranges. This stage involves using SIPOC to analyze the supplier and customer, and collecting VOC for the customer.

The data is ultimately collated into a project charter. During the measurement stage, flowcharts and line graphs are primarily used to collect data within the range defined in the previous stage, organizing the data into problem points. In the analysis stage, brain storming, cause-and-effect diagrams, and Failure Mode and Effects Analysis (FMEA) are conducted to assess possible causes and analyze the priority improvement sequence. An improvement plan is formulated during the improvement stage. The control stage involves process control to ensure problems do not reoccur and to maintain operating standards.

Problem Description
Company mainly deals with machining of nine different types of flanges.
The sequences of process followed in this company is,

- Primary machining
- Secondary machining
- Finishing
- Powder coating
- Inspection and separation
- Oil treatment
- Heat treatment
- Packing

We made a study on all the processes and identified a difficulty in the inspection and packing section of the company. Currently in the packing section separation of flanges are done by visual inspection method. The flanges manufacturing in this company is look similar but the physical parameters like length, diameter, weight, depth and inner diameter etc. are different. Due to the similarities of flanges, there is some mix up error occurring during packing section.

Hence in this project we are designing a flange mix up detection system which is based on both mechanical and electrical components and the entire system is mounted on a conveyor system to increase the easiness of classification.

Types of Flanges
In the machining department of BGLB the Flanges are separated Majority by 4 Families. IN that Family 1, Family 2, Family 3 have each part types of flanges whereas Family 4 has three types of flanges. The flanges are categorized by their weights. The below table shows the family of flanges separated by their weights.

Family	**Types**	**Weight**
Family 1	031	424 gms
	709	392 gms
Family 2	168	742 gms
	863	741 gms
Family 3	359	523 gms
	365	490 gms
Family 4	286	432 gms
	506	423 gms
	943	432 gms

Differences in Families
The differences in families of flanges are tabulated based on their differences in Total length, Bore length and Bore diameter.

Family 1 Difference

Types	Total length	Bore length	Bore diameter
031	31	7.6	22
709	31.2	7.6	26

Family 2 Differences

Types	Total length	Bore length	Bore diameter
168	44	17	22
863	44	19	22

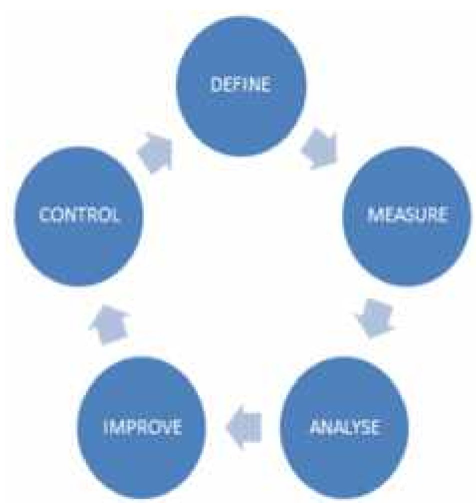
Family 3 Differences

Types	Total length	Bore length	Bore diameter
395	41.25	17.5	22
365	41.2	17.5	26

Family 4 Differences:

Types	Total length	Bore length	Bore diameter
506	29.6	17.3	31
286	41.1	17.3	31
943	41.1	17.45	31

DIMAC Process



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Define Phase

The Define Phase is the first phase of the Lean Six Sigma improvement process. We used the classic tool here called SIPOC which stands for Suppliers, Inputs, Process, Outputs and Customers. Here our customers are internal component of the organization.

During the Define phase,we contact customers to better understand their requirements of the process, or the "Voice of the Customer." After interviewing or surveying customers, we translate that information to find out the drilldown parameters. Then we tabulated Project Y and SIPOC tables to improve the process or solve the problem.

Voice Of Customer(VOC)	Sorting the flanges
Critical To Satisfaction(CTS)	Improve productivity rate
Critical To Quality(CTQ)	➢ Bore diameter ➢ Length ➢ Weight ➢ Geometrical structure
VOC to CTQ drill down Parameter	" Weight " is selected as the main parameter
Voice Of Design(VOD)	Weight
Defect opportunities(DO)	Weight
Voice OF Process(VOP)	Weight

Project "Y"

- The specific measurable improvement, drilled down from the voice of customer
- The project "Y" should be measurable , controllable , tractable (to customer CTQ)

Priority no :		**Family 1**		**Family2**		**Family 3**		**Family 4**		
		031	709	168	863	359	365	286	506	343
Weight	9	424	392	742	741	523	490	432	423	432
Total length	5	31	31.2	44	44	41.25	41.2	29.6	41.1	41.1
Band length	5	7.6	7.6	17	19	17.5	17.5	17.3	17.3	17.45
Bore length	7	22	26	22	22	22	26	31	31	31

We choose weight as our major priority because the bang length, bore length , and total length measuring is difficult and also the expense will be greater . Weight can be easily measured and easy to separate the flanges with respect to the families

SIPOC

In process improvement, a SIPOC (sometimes COPIS) is a tool that summarizes the inputs and outputs of one or more processes in table form. The acronym SIPOC stands for **s**uppliers, **i**nputs, **p**rocess, **o**utputs, and **c**ustomers which form the columns of the table.[1][2] It was in use at least as early as the Total Quality Management programs of the late 1980s and continues to be used today in Six Sigma and Lean manufacturing.

Supplier	Input	Process	Output	Customer
Forging	Dealer	Raw material	Industry	Procurement Engineer
Procurement Engineer	Industry	Primary machining	CNC mc1	CNC mc1
CNC mc1 worker	CNC mc1	Secondary machining	CNC mc2	CNC mc2
CNC mc2 worker	CNC mc2	Finishing	Sand blasting	Sand blasting
Sand blasting	Sand blasting	Powder coating	Powdering worker	Powder coating
Powdering worker	Powdering	Inspection and separation	Inspector and separator	Inspection and separation
Inspection and separation	Inspector and separator	Oil treatment	Oiler	Oiler
Oiling worker	Oiler	Heat treatment	Heater	Heater
Heating worker	Heater	Packing	Shipment	Shipment

Measure Phase

In measure phase we tabulated input, process and output measures to find out which is the main parameter. Then the effectiveness and efficiency are measured. After that cycle time and wastage time are tabulated and based on the table we plotted corresponding graphs on Value added and Non-Value added time.

Input, Process and Output Measures

INPUT	PROCESS	OUTPUT
MACHINE OPERATOR	Heating	Sorting of flange
	Motion	Productivity improvement
	Sensing	Economic growth
	Spraying	

From process parameters, we choose ‘Sensing’ as the main parameter, because sensing is the initial process only after sensing other processes can be done.

Effectiveness Measures

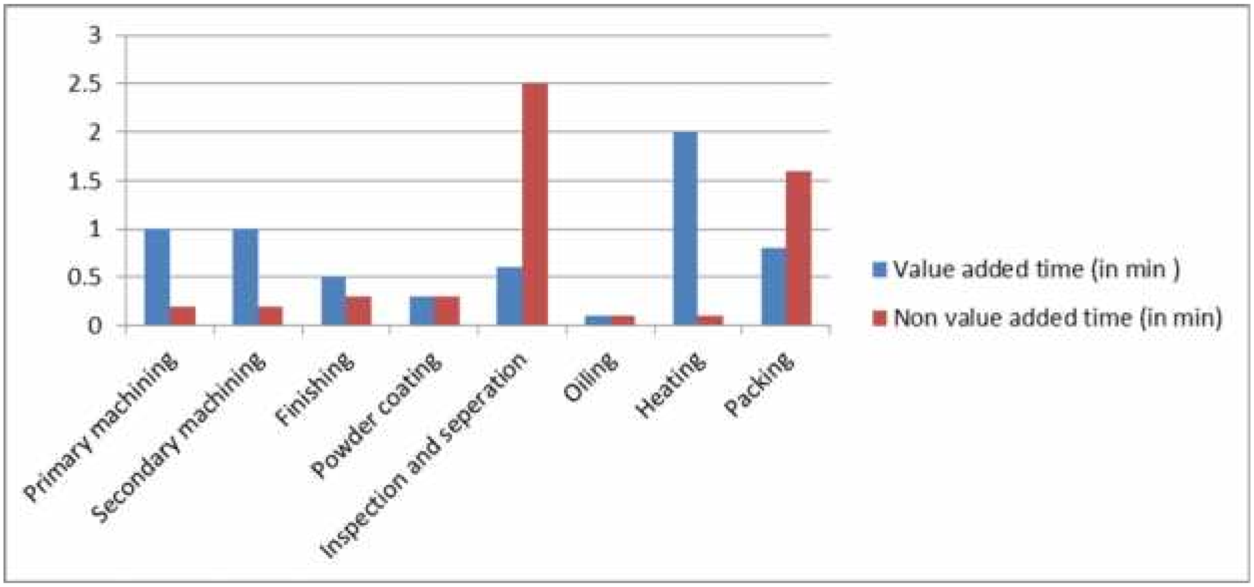
- Low Scrap Rate
- Low Inventory

Effeciency Measures

- High Productivity
- Low Process time

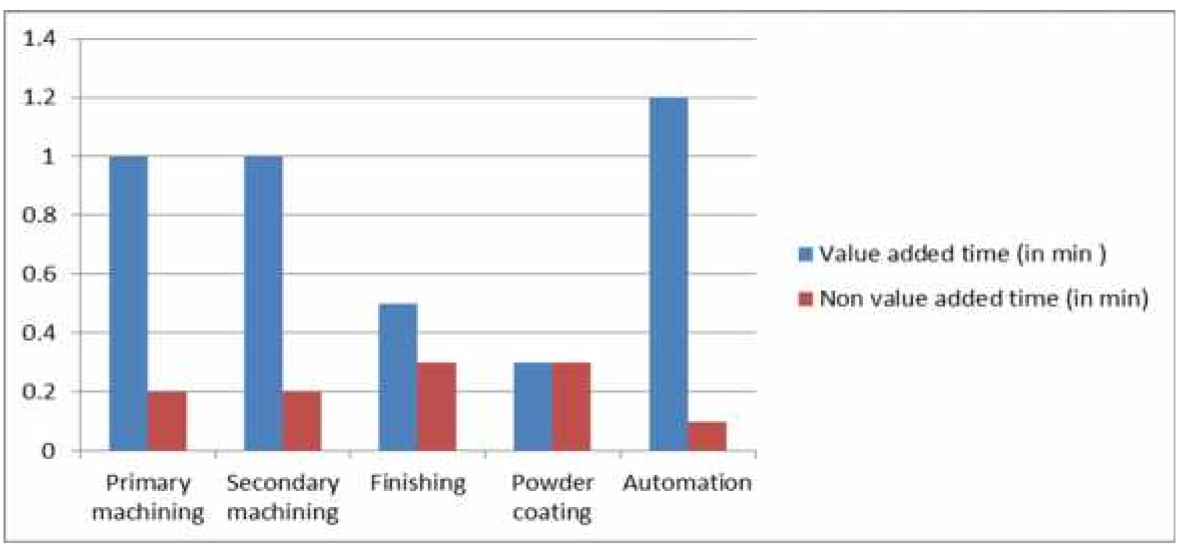
Cycle Time

Name of process	Cycle time (in min)
Primary machining	1
Secondary machining	1
Finishing	0.5
Powder coating	0.3
Inspection & separation	0.6
Oiling	0.1
Heating	0.2
Packing	0.8



Wastage Time

Name of process	Wastage time
Primary machining	0.2
Secondary machining	0.2
Finishing	0.3
Powder coating	0.3
Inspection & separation	2.5
Oiling	0.1
Heating	0.1
Packing	1.6



Analyse Phase

After creating, verifying and examining detailed process maps created in the Measure Phase, We were able to list concerns or pain points within the process. This allowed us to take advantage of the collective wisdom of process. Then we determine the value of each step by performing analyzing the process by performing "Process Analysis" which consists of:

Time Analysis: focuses on the actual time work is being done in the process in versus the time spent waiting. What teams discover is that whereas people are 99% busy, "things" are 99% idle.

Value Added Analysis: adds another dimension of discovery by looking at the process through the eyes of the customer to uncover the cost of doing business.

Value Stream Mapping: combines process data with a map of the value-adding steps to help determine where Waste can be removed.

Tools: Process Analysis and Data Analysis

Visually inspect the data

After data collection, we were able to display the data using charts and graphs for visual indications for problems in the process. The transformation of numbers into visuals allowed us to easily communicate their findings to leadership and other process.

Brainstorm potential cause(s) of the problem

We are able to develop theories around possible causes of the problem by brainstorming together. By using a tool called a "Cause & Effect Diagram", we were able to perform structured brainstorming that can help them narrow down to the vital few causes of lost time, defects and waste in the process.

Tools: Cause & Effect Diagram

Verify the cause(s) of the problem

Before moving on to the next phase (Improve), we must confirm the proposed root cause is creating the problem by verifying their data through process analysis, data analysis, process observation and comparative analysis.

Value stream mapping

A special type of flow chart that uses symbols known as "the language of Lean" to depict and improve the flow of inventory.

The data's are plotted in the sigma xl software, the customer demand per day for the product, workers schooled per day, no of shift worked.

On the analysis we have found out the Talk time

$$\text{Talk time} = \frac{\text{OPERATION TIME PER SHIFT}}{\text{CUSTOMER REQUIREMENT PER SHIFT}}$$

SigmaXL Lean Templates: Takt Time Calculator

Daily Customer Demand:	units per day	3500
Scheduled Work:	hours per shift	8
Shifts per Day:		2
Lunch:	minutes per shift	20
Breaks:	minutes per shift	10
Planned Downtime:	minutes per shift	5
Staff/Operator Cycle Time:	minutes per unit	7.25
Available Time:	minutes per day	900.0
Takt Time:	minutes per unit	0.3
Required Number of Staff/Operators:		28.2

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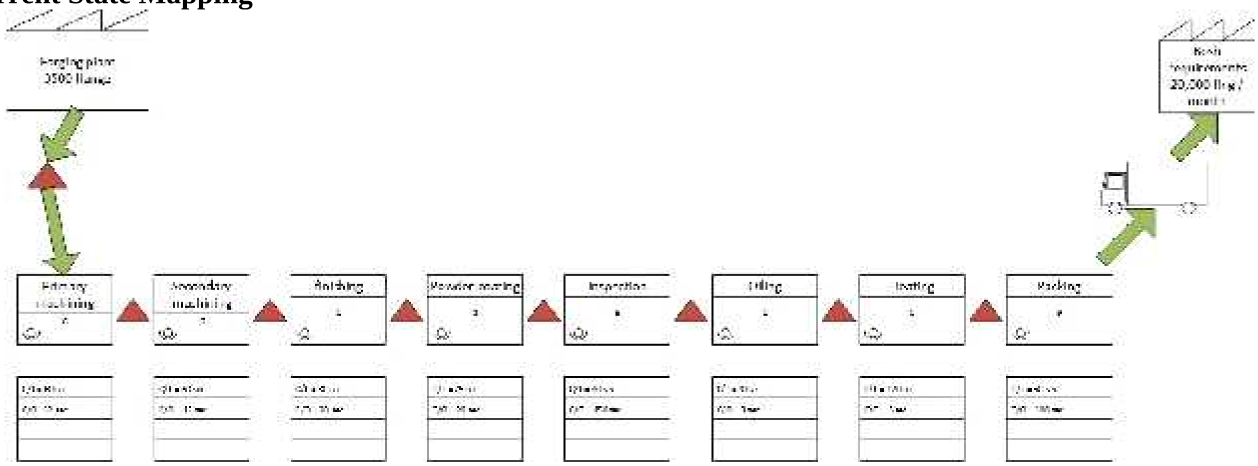
Current State Mapping

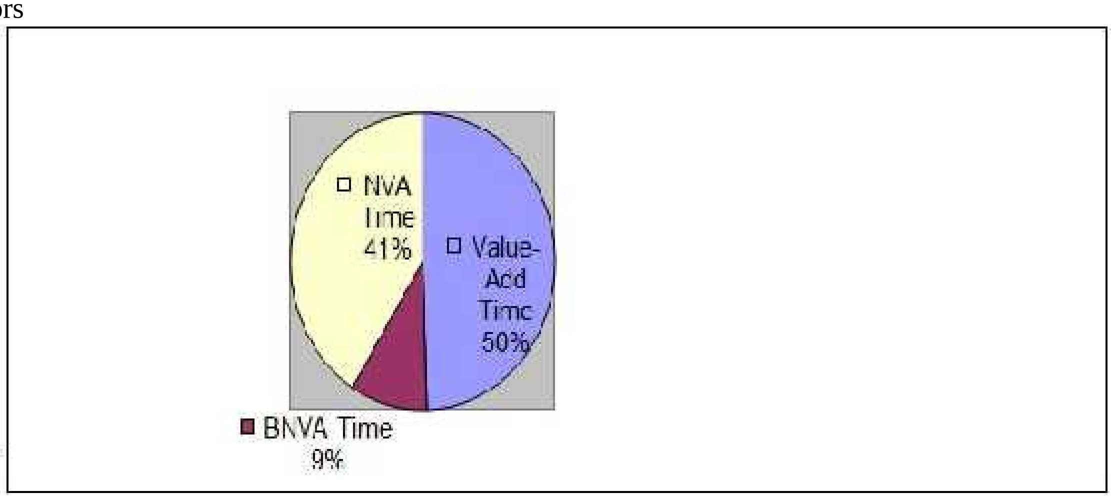


The above map shows the entire flow of process in the industry, from the entering of raw materials to shipment. This is a detailed process map showing time for each process and workers related with value added time and non value added time.

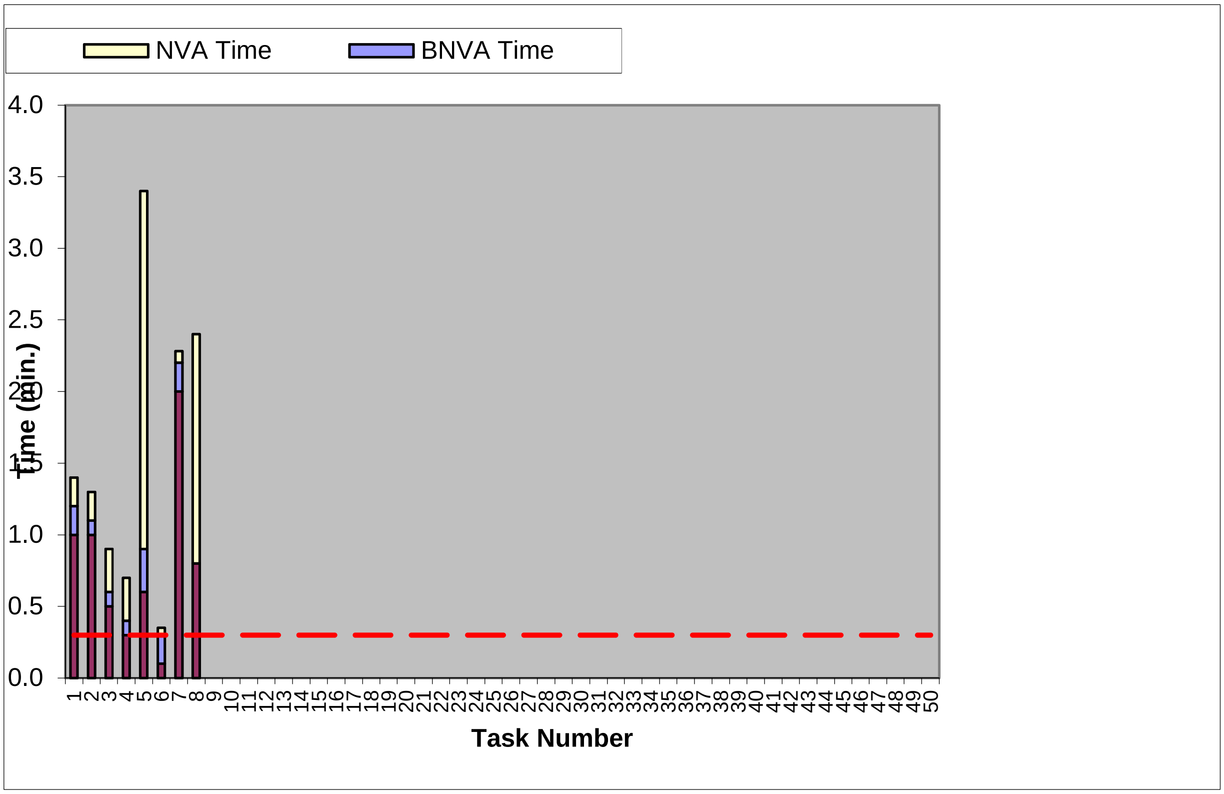
Enter Takt Time:	0.3

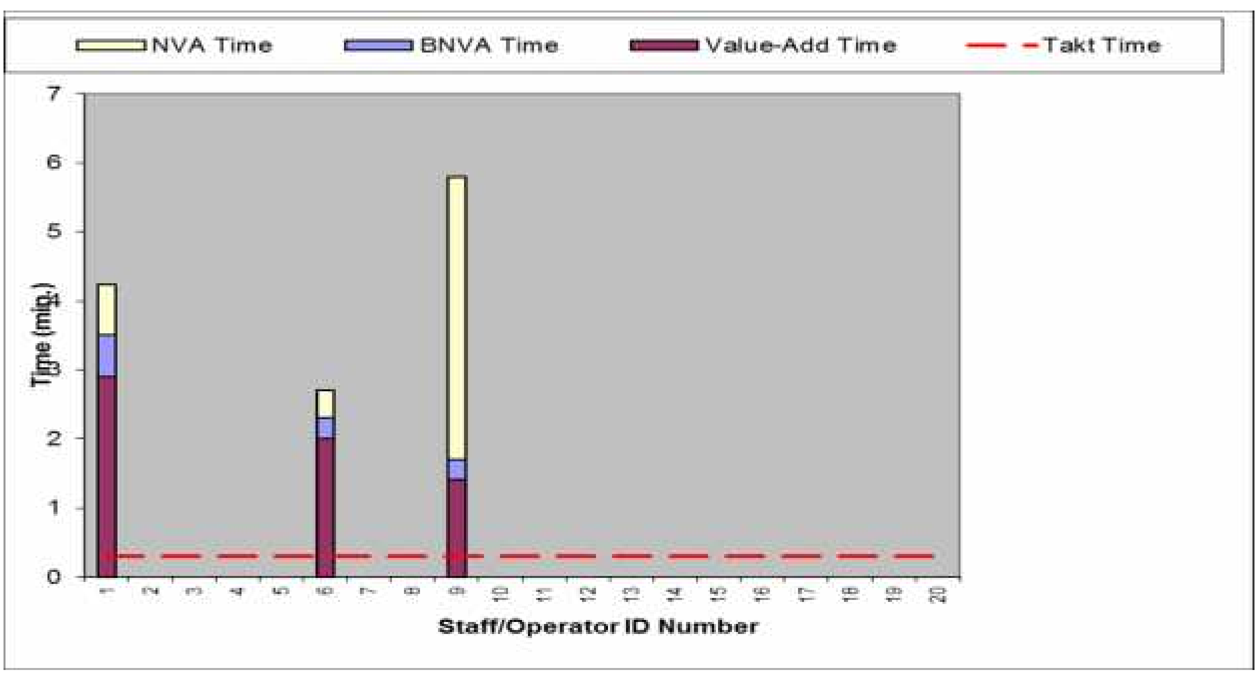
Task Number	Staff/Operator ID	Task Description	Value-Add Time	BNVA Time	NVA Time	Total Time
1	6	Primary Machining	1.0	0.2	0.2	1.4
2	6	Secondary Machining	1.0	0.1	0.2	1.3
3	1	Finishnig	0.5	0.1	0.3	0.9
4	1	Powder Coating	0.3	0.1	0.3	0.7
5	9	Ins & Sep	0.6	0.3	2.5	3.4
6	1	Oiling	0.1	0.2	0.1	0.4
7	1	Heating	2.0	0.2	0.1	2.3
8	9	Packing	0.8	0.0	1.6	2.4

The Above table shows the calculation of value added and non-value added time with repect to staff and number of operators



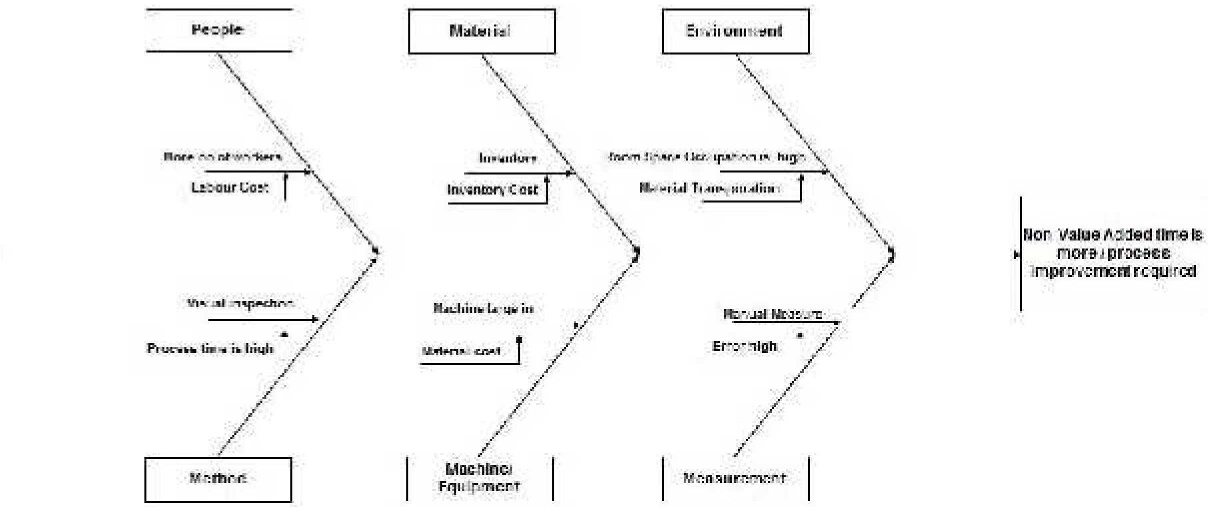
After theIinitial analyzing we have found the non Value added time as 41%.The waste time in the total process is about 41%.The improvement must be showed in the process





Cause and Effect Diagram

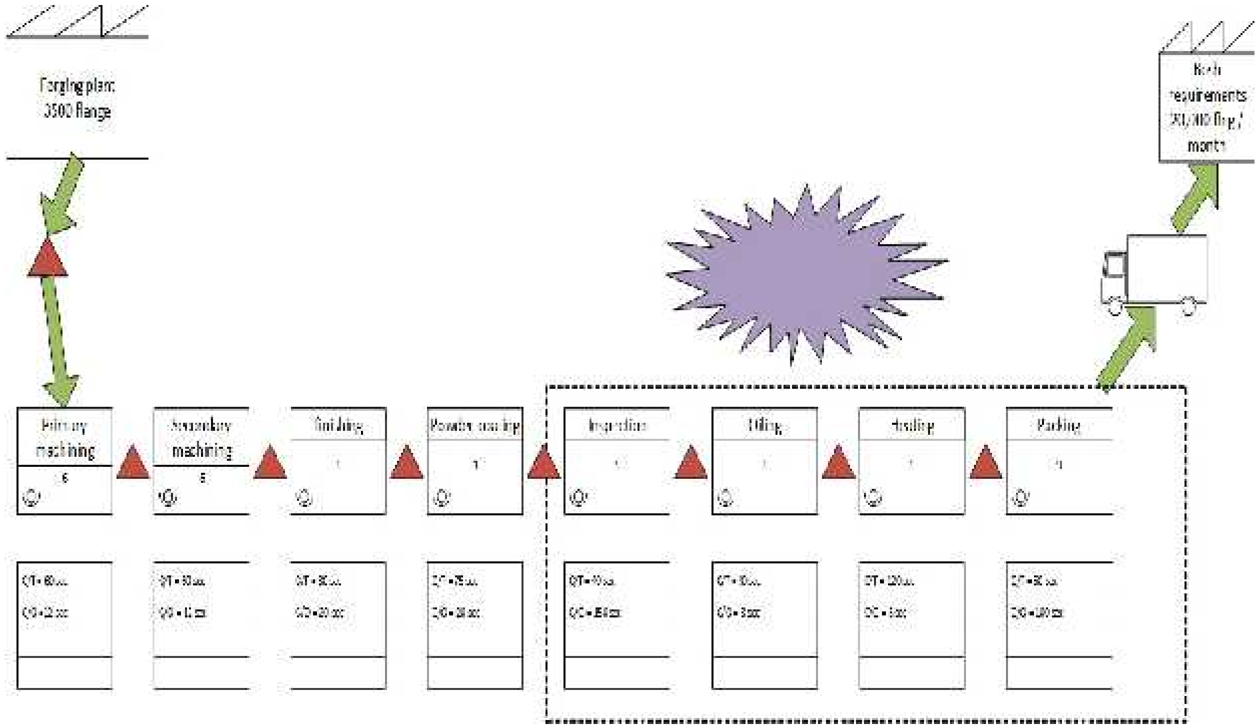
A Cause-and-Effect Diagram is a tool that helps identify, sort, and display possible causes of a specific problem or quality characteristic . It graphically illustrates the relationship between a given outcome and all the factors that influence the outcome. This type of diagram is sometimes called an "Ishikawa diagram" because it was invented by Kaoru Ishikawa, or a "fishbone diagram" because of the
way it looks.



Improve Phase

In improve phase, for improving value added time we combined inspection, oiling, heating and packing processes into one single process called automation. The non value added time is reduced here .By employing Kaizen Burst in current phase diagram we obtained future phase and improved phase diagram.

Defect Founded



On analysis we found requirement for automation ,so the above picture shows areas on concentration.

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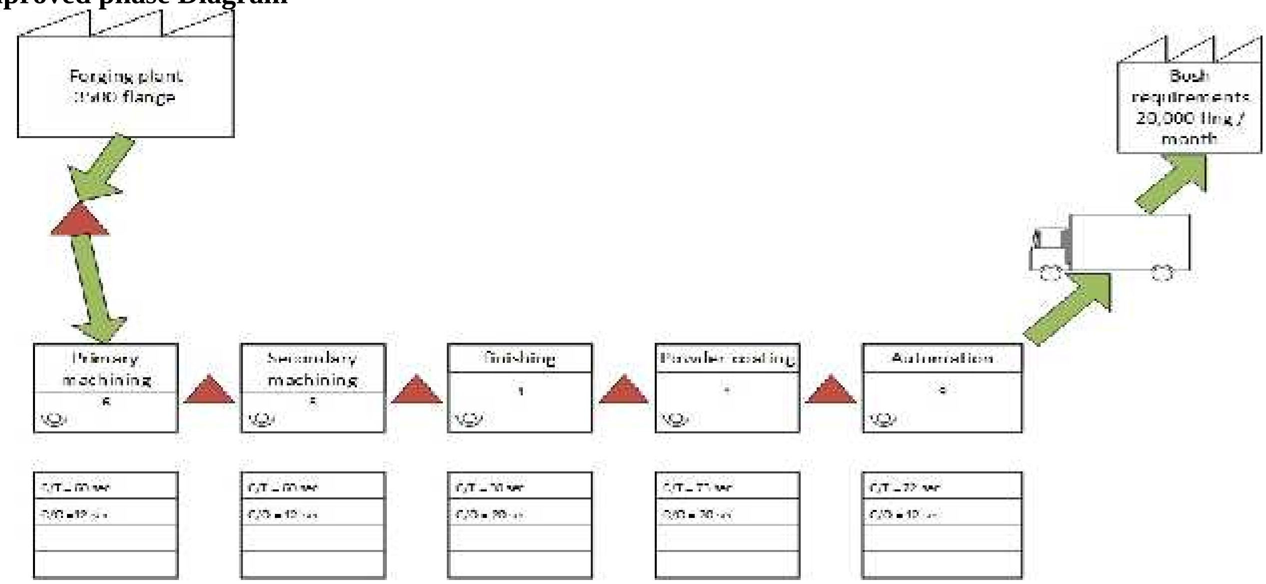
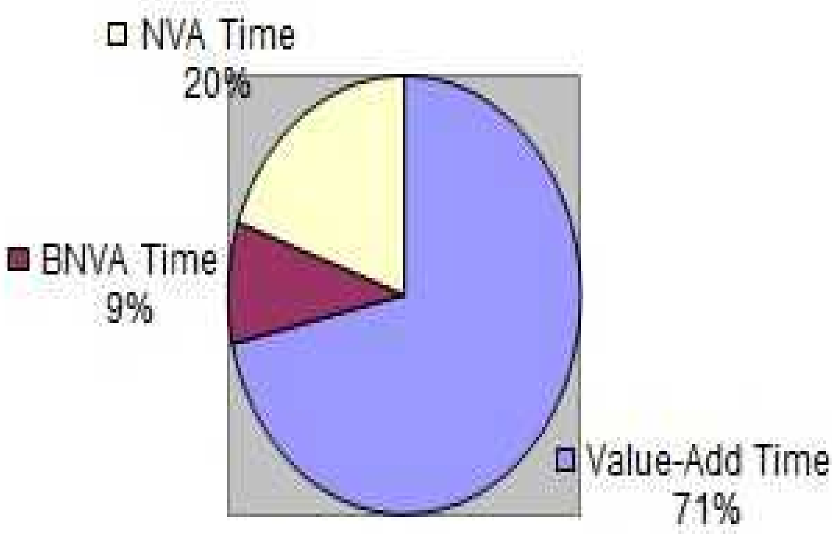
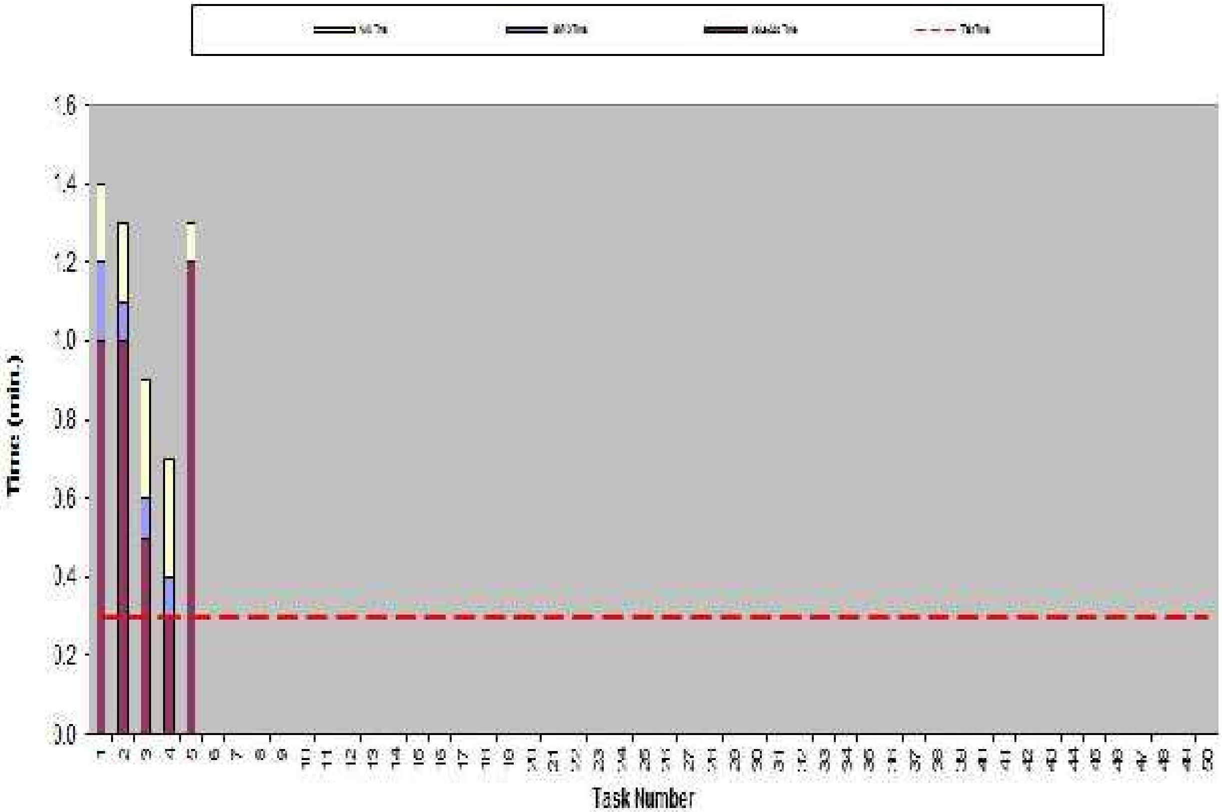
Improved phase Diagram

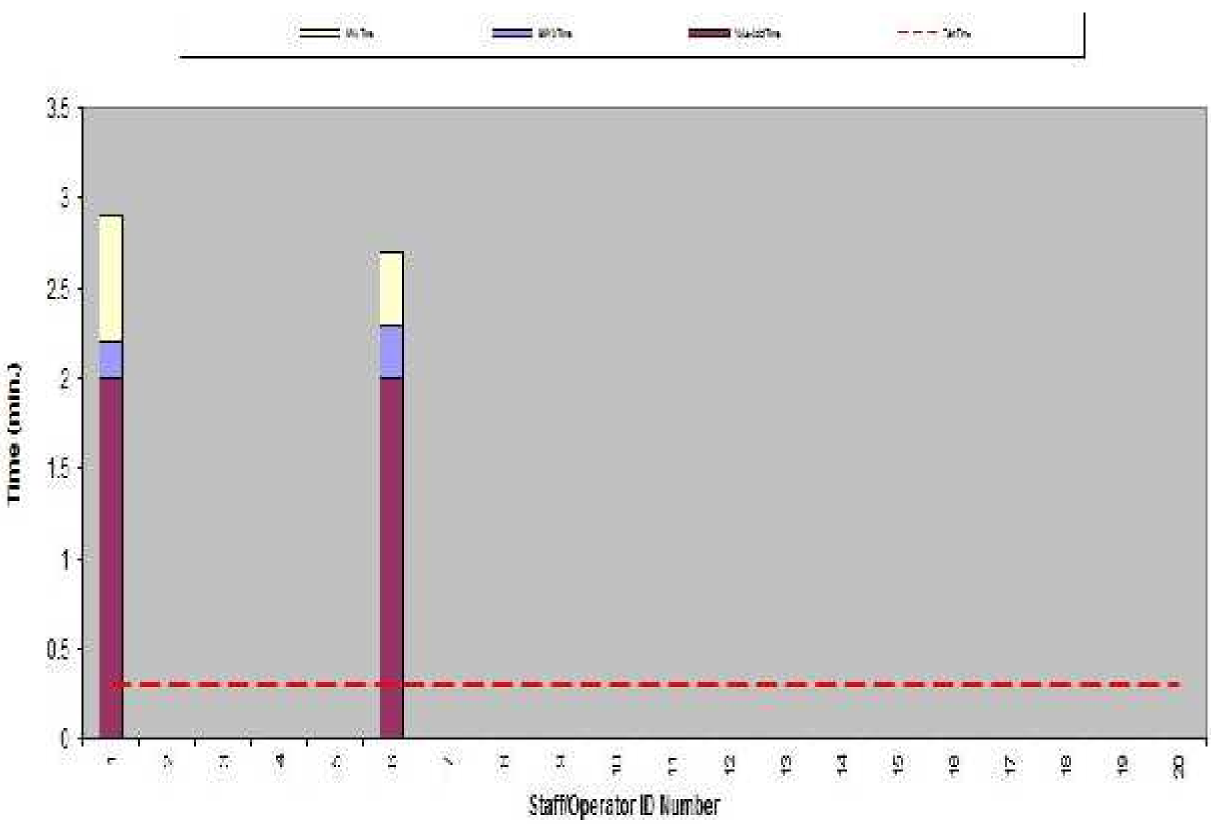


Enter Takt Time:	0.3

Task Number	Staff/Operator ID	Task Description	Value-Add Time	BNVA Time	NVA Time	Total Time
1	6	Primary Machining	1.0	0.2	0.2	1.4
2	6	Secondary Machining	1.0	0.1	0.2	1.3
3	1	Finishing	0.5	0.1	0.3	0.9
4	1	Powder Coating	0.3	0.1	0.3	0.7
5	1	Automation	1.2	0.0	0.1	1.3




Time (min.)
Task Number


Time (min.)
Staff/Operator ID Number

SigmaXL Lean Templates: Takt Time Calculator		
Daily Customer Demand:	units per day	3500
Scheduled Work:	hours per shift	8
Shifts per Day:		2
Lunch:	minutes per shift	20
Breaks:	minutes per shift	10
Planned Downtime:	minutes per shift	1.7
Staff/Operator Cycle Time:	minutes per unit	5.8
Available Time:	minutes per day	900.0
Takt Time:	minutes per unit	0.3
Required Number of Staff/Operators:		22.6

Control Phase

This phase is a mini version of process management. We had been building a form of infrastructure throughout the life of the project, and during the Control Phase we begin to document exactly how they want to pass that structure on to the employees who work within the process.

Continuously Improve the Process Using Lean Principles

The four principles of Value, Flow, Pull and Perfection should remain a constant focus for every organization. As Continuous Improvement we hand over the results of each project, they must make efforts to relay this focus to the employees using the newly improved process. The process can always be improved.

Value: Determine what steps are required (are of “Value”) to the customer Flow: Remove Waste in the system to optimize the process to achieve a smoother pace Pull: Ensure the process responds to customer demand (“Pull” = want)Perfection: Continuously pursue “Perfection” within the process.

Ensure the Process Is Being Managed and Monitored Properly

In order to maintain this focus, we must narrow down the vital few measurements they want to maintain for ongoing monitoring of the process performance. This monitoring is accompanied by a response plan indicating the levels at which the process should operate and what to do in the case that the process should exceed those levels. This may lead to continued process refinement.

Tools: Control Plan, Response Plan, Control Chart and Documentation

Expand the improved process throughout organization

At this point, we must update their documentation: process maps, document checklists, cheat sheets, etc. The better their final documentation, the easier it will be for process participants to adopt the new way of doing things.

Conclusion

In this case study we have identified the various aspects such as non-value added time, improper human resource maintenance, on the whole of analysis we have cut down the total productivity time and improved the production rate by“49 %”.And also we reduce the working labor from 28 to 22.